Dynamics of fragment capture in ^{7}Li + ^{198}Pt

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Introduction

The process of breakup/incomplete fusion where one of the fragments after breakup of the projectile is captured by the target, has been found to be more dominant over one step transfer in case of ^{6}Li(^{7}Li) for deuteron (triton) capture [1–3]. For well bound projectile incomplete fusion occurs only at high energies (≈ 10 MeV/A or more). In case of weakly bound clusters of ^{6,7}Li, this is an important channel both at high energies and at energies much below the barrier. The present work is aimed at studying the process of capture/transfer for the weakly bound ^{4}He, ^{3}H clusters and the tightly bound heavy fragments, ^{5,6}He of ^{7}Li using the particle-gamma coincidences. Integrated cross-section of compound nuclear fusion, ^{3}H and ^{4}He-capture, required for constraining parameters of theoretical calculations, have also been measured. Results are compared quantitatively with the recently developed three-dimensional classical model of breakup fusion [4]. The present work for the first time enabled to distinguish the influence of weakly bound and well bound cluster structures on reaction dynamics.

Experimental Details

The experiment was performed at 14UD Pelletron Facility-Mumbai in two parts: coincidence measurement of outgoing fragment with prompt γ-rays emitted from the residues and measurement of the integrated cross-section of fusion, t -capture using off-beam and α-capture using in-beam γ-ray spectroscopy methods [5]. The coincidence measurement was performed with ^{7}Li beam of energy 45 MeV, incident on a 1.3 mg/cm^{2} thick self supporting foil of ^{198}Pt having 95.7% enrichment. Four telescopes (ΔE∼25-30μm and E∼1mm) at 50°, 60°, 120° and 130° were used to detect the outgoing fragment. Four efficiency calibrated Compton suppressed clover detectors were placed at 14.3 cm from the target position at angles of 35°, -55°, 80°, and 155°, to measure the γ-rays. The evaporation residues formed after capture of different fragments (^{4,5,6}He, ^{3}H) were identified by their characteristic γ-ray transitions from the spectrum recorded in coincidence with the outgoing fragment. Experiment for measuring cross-section of the residues resulting from the process of fusion and ^{3}H - capture were performed with beams of ^{7}Li in the range of 22 to 45 MeV incident on self supporting foils of ^{198}Pt followed by an Al catcher foil. Two efficiency calibrated HPGe detectors with a Be window were used for offline γ-ray counting. The cross-section for ^{4}He- capture forming ^{202}Hg could not be measured using this method as the resulting residues are stable (except ^{199m}Hg). These cross-sections were obtained by measuring prompt gamma ray transitions from the residues in four clover detectors, using the same setup as described above for the particle- gamma ray coincidence

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measurement.

Analysis and Summary

A three-body classical dynamical model implemented in the PLATYPUS code allows a consistent analysis of breakup, incomplete, and complete fusion processes. The integrated cross-sections of complete fusion, α-capture and t-capture for the ^{7}Li + ^{198}Pt system [5] were used to constrain the parameters of the model while predicting the differential cross-section as function of excitation energy and angular momentum. The spectrum of the surviving α-particles, can be expressed as a function of E^* deposited in the composite system ^{201}Au (inset Fig 1a), using PLATYPUS. The calculated E^* and the corresponding breakup fusion cross-section as a function of spin was given as input to the statistical model code PACE2 for calculating the evaporation residue cross-sections from decay of ^{201}Au formed after triton-fusion. The calculated values of absolute cross-sections for the residues, ^{198,199}Au, are plotted as solid and dashed curves in Fig. 1a. The measured yield of ^{198}Au from the second bin of α-particle spectrum , were normalised to the cross-section obtained from PACE2 for the E^* (= 30 MeV) that corresponds to the E_α (= 24 MeV) at center of the bin. The cross-section for ^{198,199}Au deduced after applying the same normalisation to their respective yields in each bin, are plotted in Fig. 1a. The error on cross-sections is due to the statistics. A reasonably good agreement is observed with the calculation. These results suggest that the main mechanism responsible for t - capture is fusion of t after breakup of ^{7}Li, as modeled in the PLATYPUS code. Following the same procedure, cross-sections of residues from capture of α-particles for a given energy of outgoing triton (inset of Fig. 1b) was calculated from PACE2, using spin-distribution and excitation energy of ^{202}Hg from PLATYPUS and are shown in Fig. 1b. In case of capture of strongly bound ^{5}He+d and ^{6}He+p clusters, the evaporation residues are more neutron rich than predicted from the model for fusion of ^{5}He and ^{6}He after the breakup suggesting the mechanism to be massive transfer. It would be interesting to extend such studies with radio-active nuclei having predominant weakly bound cluster structures.

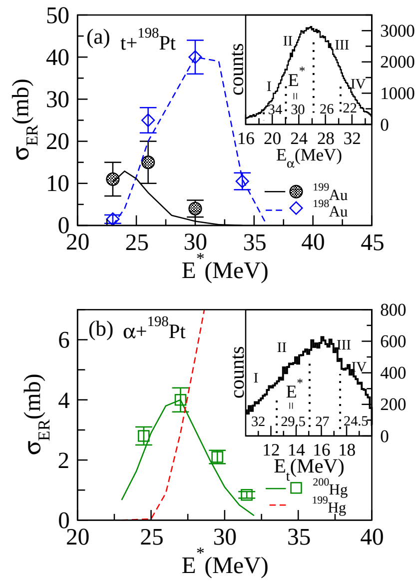

FIG. 1: (color online) Residue cross-sections plotted as a function of excitation energy (E^*) of the composite system formed after (a) t-capture . The E^* locked in ^{202}Hg is calculated from corresponding kinetic energy (E_α) of the surviving α- particle (spectrum shown in the inset) (b) is same as (a) but for α-capture. The solid and dashed curves are statistical model calculations taking the σ(J) and E^* from PLATYPUS.

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